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A FIELD TRIP TO COAL PROCESSING PLANTS IN WESTERN CANADA, FEBRUARY 28 to MARCH 4, 1977.

W. DINGLEY and G.R. HOEY

PHYSICAL SCIENCES LABORATORY

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A Field Trip to Coal Processing Plants
In Western Canada
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by

W. Dingley and G.R. Hoey

INTRODUCTION

A field trip was made to the Western Regional Laboratory (ERL), Edmonton and to the coal processing plants at Canmore and Coleman, Alberta and Kaiser Resources, Sparwood, British Columbia from February 28 to March 4, 1977. The purpose of the visit was to identify corrosion and erosion-corrosion problems in plant equipment used in coal processing.

The reasons for choosing the above four plants were (a) location, (b) size of plant and (c) variety of equipment used. Information was obtained by plant tours and discussions with plant personnel. A flow sheet was obtained from each plant. Samples of process water were collected at Canmore and Coleman for analysis.

DETAILS

Western Regional Laboratory

The coal washing pilot plant of the Western Regional Laboratory is located in the Alberta Research Council Buildings. Prior to touring the plant, a discussion was held with Ms J. Picard, the laboratory manager. She had arranged the pilot plant tour and had provided valuable assistance during the planning of the field trip. During the discussion she informed us that wear was a problem in some of the plant equipment. Mr. Magdy W. Mikhail, processing engineer in charge of the pilot plant was the tour guide.

Mr. Mikhail took us through the plant which was capable of handling 10 tph but was not operating at the time of the visit. He explained in detail the purpose of each piece of equipment and pointed out locations where wear was or had been a problem and what had been done to solve it. The plant is designed to perform four major functions: (a) feed preparation, (b) cleaning, (c) drying and (d) water recovery. The coal feed is mixed with water in a dual mixing tank prior to cleaning. The slurry from this tank is pumped to the cleaning circuit where a large percentage of the heavy middlings and refuse is separated from the coal in 8-in. compound water cyclones (CWC) and 8-in. classifier cyclones (Cl.C). The severest wear had taken place in the lower part of the cone in these cyclones. CWC cones made of Ni-hard steel or plastic have failed rapidly.

Ceramic and urethane cones will be tested in this area. Similarly the hardened manganese steel Cl.C cones have failed and replacement liners of plastic or rubber have rapidly deteriorated. Ceramic cones recently installed appear to be an improvement over other materials tested. Mr. Mikhail pointed out that this type of problem was common in commercial coal processing plants. The washed coal slurry passes over 304 stainless steel Dutch State Mines (DSM) dewatering screens. The efficiency of these screens depends on the sharp leading edge of its horizontal bars. Wear by the slurry dulls the edges rapidly resulting in the coal and water being poorly separated. By design the dulled edges can be resharpened by reversing the screen so that the slurry flows over the bars in the opposite direction. One method used to separate fine coal from shale is to add a chemical flotation agent to the slurry and pass it through a flotation cell. The coal is floated by air agitation and the shale is removed as tailings. Air jets in the slurry produced both the agitation and aeration necessary in the flotation cell. Wear had not been a problem in this equipment. Another separation method was by heavy media fluidized bed in which a slurry of magnetite (Fe_3O_4) and water is mixed with the coal slurry. The combined slurry is pumped through a heavy media cyclone where the fine coal is separated from the heavier magnetite and shale. The magnetite is then separated from the shale by magnetic separation for reuse. Equipment in this circuit has been extensively damaged by wear especially where it is in contact with moving magnetite slurry.

DSM screens and centrifuges are used to remove excess water from the coal. The centrifuges were constructed of 316 stainless steel and had not developed any signs of significant wear.

In the water recovery circuit a solution containing a flocculating agent was mixed with the effluent and the resulting floc was separated from the water by a pulp divider and a 4-in. Cl.C. The water was then pumped to a clarifier tank and the separated floc went to reject. No severe wear or corrosion had been observed in this equipment. The water pH throughout the entire plant was approximately pH 7.

Mr. Makhail then took us to a laboratory where there was a working transparent plastic miniature model of the CWC and Cl.C units. Mixtures of particles of different density and size were mixed with water and pumped through this model. One could visually observe how each type of cyclone classified the various particles passing through it. Worn areas similar to those observed in the pilot plant equipment were being produced in these miniature units.

A Leeds British Fi-monitor flotation laboratory system was also on display. This appeared to be an excellent compact unit for small flotation experiments.

After the tour the wear problem in the cyclone cones was discussed more fully and Mr. Makhail provided copies of CWC blueprints. It obviously was the most serious problem in the coal washing plant.

A brief discussion was held with Mr. Khalid Hashmi who had been assigned the task of locating suitable laboratory corrosion tests to determine what type of materials should be used in the construction of flocculating equipment.

Canmore Coal Processing Plant

Mr. C.W. Gregory, Executive Vice-President of Canmore Mines Ltd., informed the authors that the guide for the plant tour would be Mr. Stan Cherak, the plant superintendent. He then introduced us to Mr. R.M. Caywood, the assistant general manager who would be available to answer any questions we might have after the tour.

Mr. Cherak explained that the plant was processing about 235 tph of run of the mine semi-anthracite coal. Prior to mixing the relatively dry coal from the mine with water it was passed over screens, through a rotary breaker and then over several screens again to remove large heavy pieces of refuse such as rock, shale and debris. The underflow from the screens was conveyed to the dual mixing tank where it was mixed with recycled feed water prior to going through the second stage of the cleaning cycle. The slurry from this tank was pumped to two 24-in. compound water cyclones. The overflow was screened to remove the stoker and slack coal and the fines went to a collector tank #1. The underflow was double screened to remove the plus 1/4-in. and plus 6-mesh refuse material and the minus 6-mesh material went to collector tank #2. The slurry in collector tank #1 was pumped to four 8-in. CW cyclones. The overflow from

these cyclones was sent to either a dewatering screen and centrifuge or to a disc filter and then to the slack pile. The underflow went to tank #2 and was pumped to ten 8-in. CW cyclones. The overflow from these cyclones was combined with the overflow from the four previous cyclones prior to being dewatered. The underflow which was the most abrasive material was pumped to the tailings pond where it was allowed to settle so that the clarified water could be recycled. The residue was allowed to accumulate in the pond and then was removed and placed on the refuse pile. Water samples were obtained from the dual mixing tank and from water going to the tailings pond.

Frequent replacement of the screens, parts of cyclones (usually the lower cone section), slurry pumps, pipes and launders attest to the wear that was occurring in this plant. The wear in the cyclones was the most troublesome and various materials including plastic and rubber had failed to solve the problem. Mr. Cherak said that ceramic cones were on order. Severely worn screens were being replaced with new ones made of stainless steel. Leaking pipes and launders were being patched with mild steel or replaced with new sections made of similar material. It was obvious to the authors that the wear was caused by a combination of corrosion and low-stress abrasion (erosion-corrosion).

After the tour Mr. Caywood informed us that the plant had a chemical laboratory which analysed the various waters used in and expelled from the plant, and for the carbon content of the washed coal and the tailings sent out to refuse. The moisture

content of the washed coal was also determined. He supplied a flow sheet of the plant and a typical water analysis report. The pH of the water throughout the plant was reported to be pH 8.5.

CANMET analyses of the water samples produced the following:

Sample	pH	Cl (ppm)	SO_4 (ppm)
Dual Mixing tank	7.58	0.7	414.0
Tailings pond	7.5	1.4	-

Coleman Collieries (Vicary Creek) Processing Plant

The processing plant superintendent Mr. Ray Whitehouse met the authors at the office and then took them on a tour of the Vicary Creek processing plant. This plant was processing approximately 7000 tpd of coal blended from underground and surface mines.

The dry coal stored in various hoppers was fed onto a conveyor belt at controlled rates to obtain the desired blend. It then passed through a 2-in. rotary breaker and over a 2-in. screen to remove large refuse material that had not been reduced in size. The underflow was mixed with water and passed through a Baum jig to gravity separate the coal from the heavier materials. The latter went to refuse and the overflow was double screened to remove the plus 3/4-in. and minus 3/4-in. to plus 1/8 in. coal fractions. The plus 3/4-in. material was dewatered and

conveyed to the product pile. The minus 3/4-in. to plus 1/8-in. material went to the water cyclone circuit and minus 1/8-in. material to the classifying cyclone circuit. DSM water cyclones (24-in.) were used in the primary separation and eight inch in the secondary. The overflow from the 24-in. cyclones went over dewatering screens and then to a centrifugal drier. The underflow went to the 8-in. cyclones from which the overflow went back to the primary sump and the underflow was screened, passed through a cyclone and disc filter to remove the refuse material prior to recycling the water.

The minus 1/8-in. raw coal was pumped to the cyclone classifiers where the overflow went back to the head tank and the underflow went either to Diester tables and then to a cross flow screen or direct to the latter. The overflow from the screen passed through centrifugal driers and then to the product pile. The underflow was treated with 0.1% Nalcolite flocculant and fed into a static thickener. The overflow from the thickener was pumped to the head tank and the underflow was disc filtered to remove the fine coal as residue. This coal was passed through a drier system and conveyed to the product pile.

The washed coal was reported to contain 0.32% sulphur, 11% ash and 8% moisture. A sample of water obtained from the primary sump and analysed at CANMET had a chloride content of 9.7 ppm, sulphate of 62.0 ppm and a pH of 7.58. Analyses of the refuse in the tailings piles by the company have revealed that it contains considerable coal. It has been estimated that at least 35% of the refuse consists of recoverable coal and methods of reprocessing it are being considered.

Wear in the cones of cyclones, especially the Visman modified DSM type, was producing a problem in this plant as it had in the Edmonton and Canmore plants. The compound cones made of Ni-hard were failing rapidly and a ceramic "Refrax" cone was being tested. Mr. Whitehouse stated that he would share the cost of producing a cone from a more wear resistant steel alloy, possibly 440C as suggested by the authors.

Stainless steel types 304 and 316 had been used extensively throughout this plant in the construction of equipment and as liners in various critical areas where wear had been a problem. Mr. Whitehouse pointed out that during 35 years in the plant he had learned from bitter experience that wear was a major problem and that it could be substantially reduced by using stainless steel. He maintained that the initial high cost of these alloys was soon compensated for by reduced maintenance costs and increased production. Stainless steels (304 and 316) are noted for their corrosion resistance but are not particularly resistant to abrasion. The reverse is true for Ni-hard.

Flow sheets of the plant and a copy of a blue print of the C.W. Cyclones were provided at the end of the tour.

Kaiser Resources Wash Plant (Sparwood B.C.)

Mr. Gilbert Brust, superintendent of the Kaiser Resources wash plant, informed us that the plant was not operating due to major alterations and repairs. However he assigned Mr. Jeff Palmer a plant engineer to be our tour guide. The plant

processes approximately 1400 tph of surface coal which is transported via conveyer belts from the open pit, through a tunnel in a mountain to the 10th floor of the wash plant.

The wash plant was laid out in two complete circuits operating side by side with various interconnecting links and spare equipment at strategic locations. The raw coal is fed through a selector gate that feeds each circuit and then water is added. The wet raw coal passes over several prewet fixed screens to separate the coarse from the fine. The coarse overflow goes to primary heavy media vessels where the coal is gravity separated from the refuse then the coarse clean coal passes over screens to obtain three size fractions. The refuse after passing over washing screens is conveyed to the tailings pile. The underflow from the latter screens and the coarse clean coal screens are combined and pumped through classifying cyclones then to heavy media separation where slurries containing 30 to 40% magnetite are used.

The raw fine coal from the classifying cyclones are combined and passed over desliming screens. The overflow is mixed with magnetite slurry and passed through primary heavy media cyclones. The underflow from these cyclones goes to secondary heavy media cyclones. The overflow from the latter goes to product and the underflow goes to refuse. The underflow from the desliming screens goes to the primary hydrocyclones. The overflow from the latter goes over rapped sieve bends (r.s.b.) and out to product. The underflow goes to flotation cells where

fine coal is floated and sent to product and heavy material goes to a refuse thickener. The underflow from the primary hydrocyclones goes to secondary hydrocyclones from where the overflow is sent back to the primary hydrocyclones or to the flotation cells. The underflow goes to a refuse thickener and then to the refuse pond or it can be sent direct to the pond. Clean coal fines containing excess water are put through a drier before going to product. Magnetic separators are used to remove the magnetite from clean coal and from refuse material. Thickeners are used to remove excess water from the cleaned magnetite slurry.

The fact that this plant was not operating during the tour afforded the authors an excellent opportunity to examine the various pieces of equipment and view actual areas where wear had occurred. The open chutes and launders revealed numerous worn areas, some that had nearly penetrated steel 3/8-in. thick. Liners and repair patches of "Boralloy" steel had been welded over many similar areas and these were also showing signs of wear. The composition of Boralloy steel and the company producing it are unknown to the authors. Mr. Palmer indicated that it was an abrasion resistant alloy. Repair patches were observed on the exterior of large launder pipes particularly at or near bends. Wear was more prevalent in areas where magnetite slurries were used. Ceramic cones were used in the various cyclones and according to Mr. Palmer they were giving reasonable service. The impellors in the flotation cells were lined with

neoprene rather than rubber because the latter is attacked by kerosene which is used in the flotation process.

A copy of the Kaiser Resources wash plant flowsheet was provided after the tour.

SUMMARY

1. Wear (erosion-corrosion) in coal processing plants in Western Canada causes premature failure of equipment.
2. The high hardness alloys - Boralloy and Ni-hard-are used in the plants to reduce wear but results are not satisfactory.
3. Wear in cyclone cones is the most serious problem. Although ceramic cones are more resistant then Ni-hard cones, plant superintendents have pointed out that this problem has not been solved. One superintendent offered to share the cost of producing a cone from a suitable wear resistant alloy.
4. Corrosion resistant alloys minimize many of the wear problems as shown by the stainless steels used in the Coleman plant.